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Chen et al.

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(54) **THREE DIMENSIONAL PRINTING APPARATUS**

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(30) **Foreign Application Priority Data**

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B29C 67/00 (2006.01)
B33Y 30/00 (2015.01)
B29L 9/00 (2006.01)

(52) **U.S. Cl.**

CPC ***B33Y 30/00*** (2014.12); ***B29C 67/007*** (2013.01); ***B29C 67/0066*** (2013.01); *B29L 2009/00* (2013.01)

(58) **Field of Classification Search**

None
See application file for complete search history.

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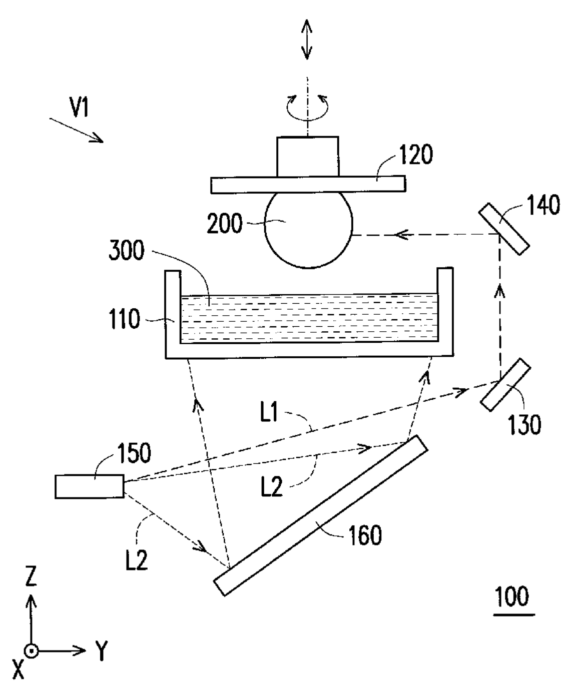
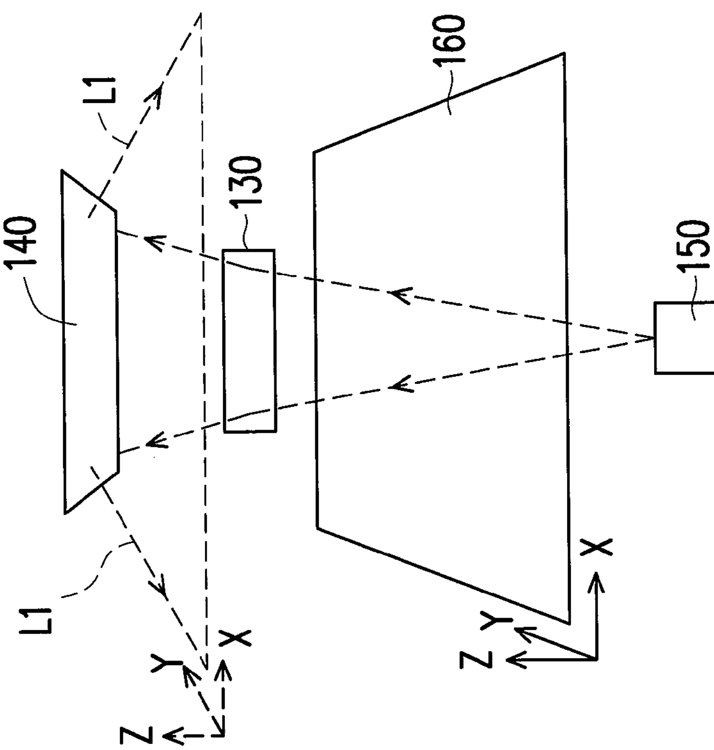
(57) **ABSTRACT**

A three dimensional printing apparatus including a tank, a modeling platform, a first optical element, a second optical element, and a light source is provided. The modeling platform is movably disposed above the tank so as to move in or out the tank. The first and the second optical elements are respectively disposed next to the tank, wherein the second optical element is located above the first optical element. The light source is located below the tank. After a three dimensional object is formed on the modeling platform, the three dimensional object is moved out of the tank by the modeling platform. A first light generated by the light source is sequentially transmitted by the first and the second optical elements and detour round tank to irradiate the three dimensional object.

11 Claims, 4 Drawing Sheets

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L1
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130
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L1
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X
Y
Z

FIG. 2

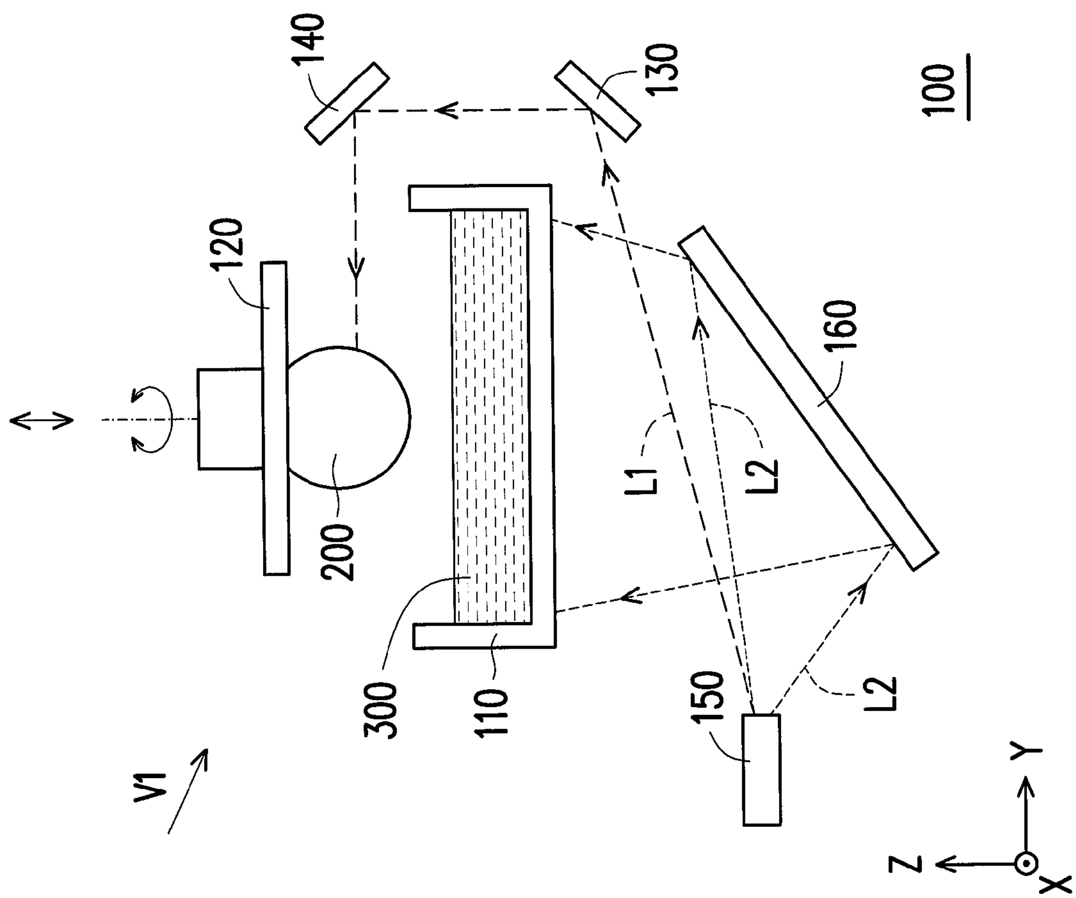
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FIG. 1

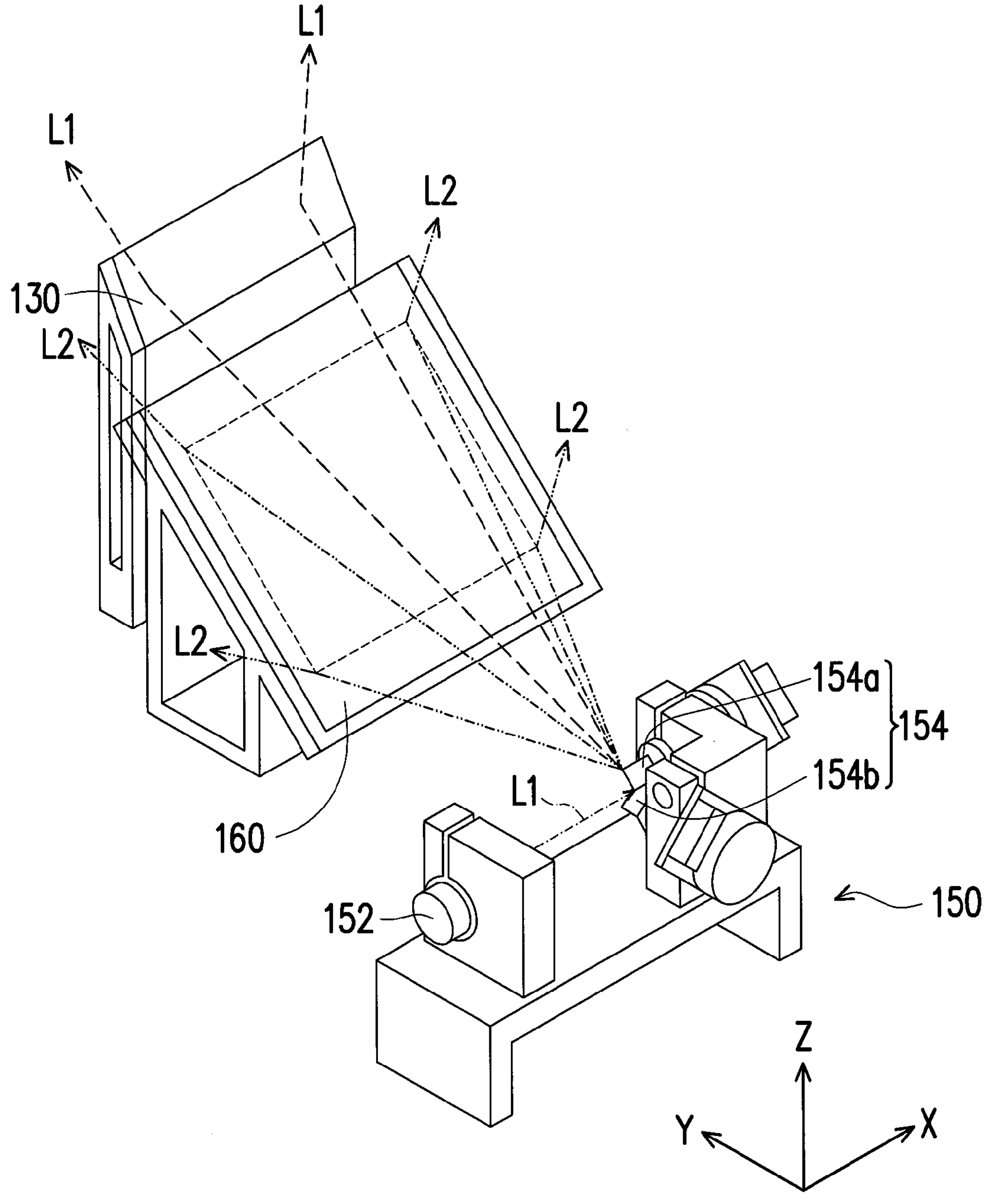

FIG. 3

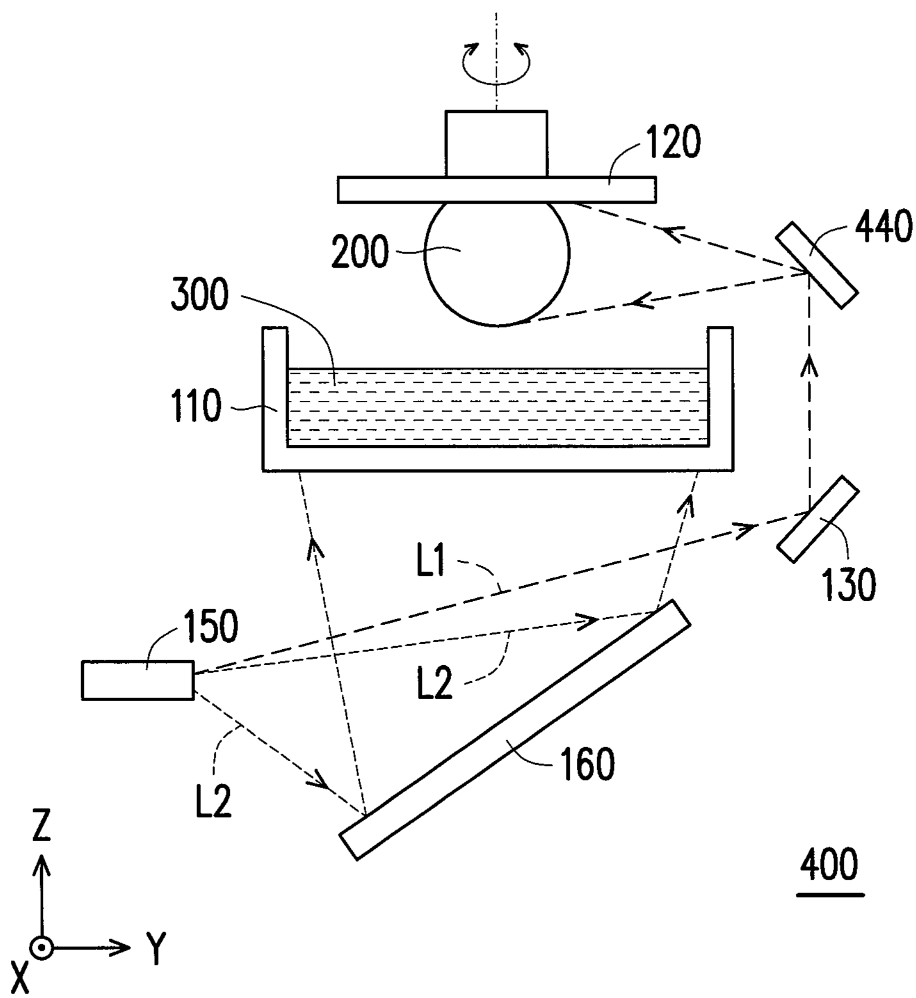

FIG. 4

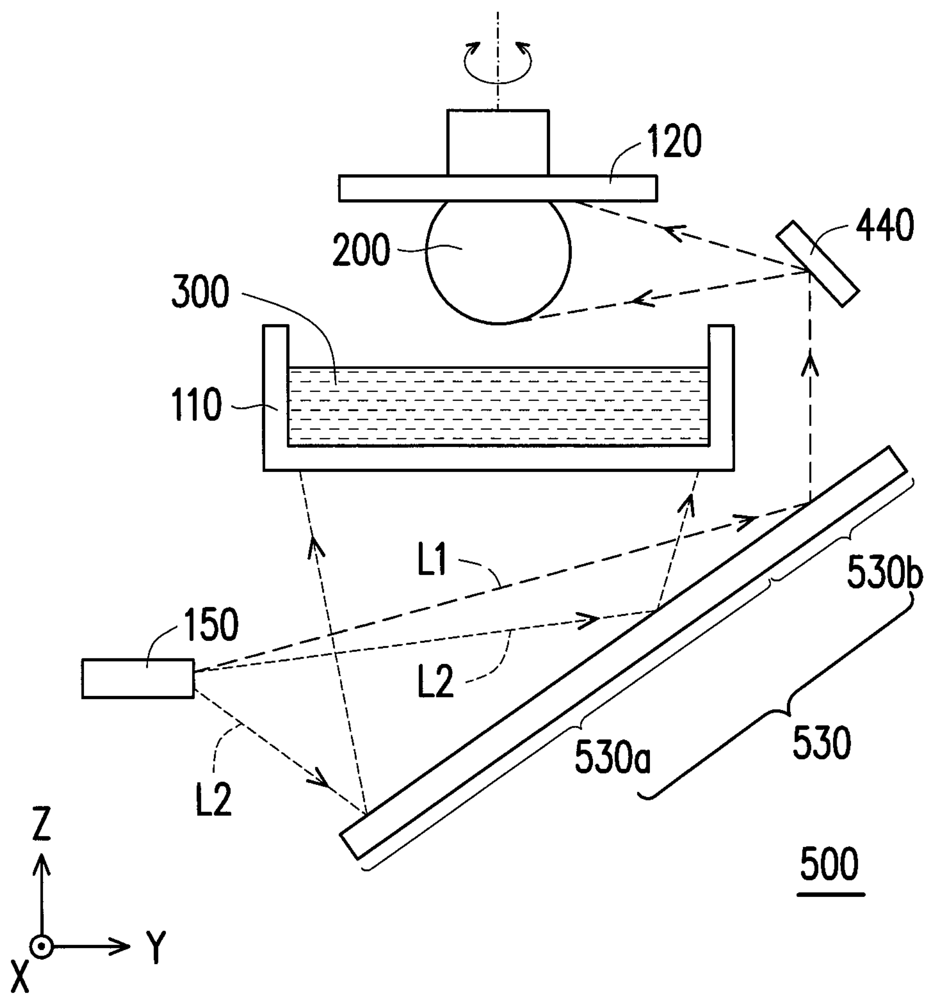

FIG. 5

THREE DIMENSIONAL PRINTING APPARATUS

CROSS-REFERENCE TO RELATED APPLICATION

This application claims the priority benefit of Taiwan application serial no. 103113685, filed on Apr. 15, 2014. The entirety of the above-mentioned patent application is hereby incorporated by reference herein and made a part of this specification.

BACKGROUND OF THE DISCLOSURE

1. Technical Field

The disclosure relates to a printing apparatus, and more particularly to a three dimensional printing apparatus.

2. Description of Related Art

In the past few years, as the technology advances, many different technologies are used to build physical three-dimensional (3-D) models using additive manufacturing technology, for example, building a model layer by layer. Generally speaking, the additive manufacturing technology is to transfer data of the design of a 3D model, which is constructed by software, such as computer aided design (CAD), to multiple thin (quasi-two-dimensional) cross-sectional layers that are stacked in sequence. In the meantime, many techniques for forming thin cross-sectional layers are also proposed. For example, a printing module of a printing apparatus is usually configured to move above a base along an XY plane according to spatial coordinates XYZ constructed according to the design data of the 3D model, so as to use a construction material to form shapes of the cross-sectional shapes accurately. Then, the deposited construction material may be cured naturally or by heating or light irradiation to form the desired cross-sectional layers. By moving the printing module along the Z axis layer by layer, multiple cross-sectional layers can be gradually stacked along the Z axis, and while the construction material is cured layer by layer, a 3D object is formed.

Take the technology that forms 3D objects by curing the construction material with a light source as an example; the printing module is configured to be immersed in a liquid forming material in a container, and a light source module is disposed to irradiate the liquid forming material on the XY plane, so as to cure and stack the liquid forming material on a movable platform of the printing module. Accordingly, by moving the movable platform of the printing module layer by layer along the Z axis, the liquid forming material can be gradually cured layer by layer and stacked to form the 3D object. However, for the known 3D printing technology, after being formed, it is necessary for the 3D object to be moved to an exposure room of the device for performing the final curing irradiation so that the exterior surface of the 3D object may be fully cured, which inevitably requires more time for the formation of the 3D object. Meanwhile, the 3D object printing apparatus needs to be equipped with an additional room for performing the final curing, which consequently costs more in fabrication of the 3D printing apparatus and increases the appearance size thereof.

SUMMARY

The disclosure provides a three dimensional printing apparatus, and its light source may simultaneously perform initial modeling and final curing to a completed three dimensional object so as to expand the applicable range.

In the disclosure, the three dimensional printing apparatus includes a tank, a modeling platform, a first optical element, a second optical element, and a light source. The modeling platform is movably disposed above the tank so as to move in or out the tank. The first and the second optical elements are respectively disposed next to the tank, and the second optical element is located above the first optical element. The light source is located below the tank. After a three dimensional object is formed on the modeling platform, the three dimensional object is moved out of the tank by the modeling platform. A first light generated by the light source is sequentially transmitted by the first and the second optical elements and detours round the tank to irradiate the three dimensional object.

In an embodiment of the disclosure, the modeling platform moves in or out the tank along an axial direction, and the modeling platform rotates in the axial direction.

In an embodiment of the disclosure, the first optical element and the second optical element are respectively reflecting mirrors.

In an embodiment of the disclosure, the first light is sequentially transmitted by the first optical element and the second optical element to scan the three dimensional object along a first plane. The modeling platform moves out or in the tank along an axial direction, and the axial direction is a normal direction of the first plane.

In an embodiment of the disclosure, the modeling platform drives the three dimensional object to rotate in the axial direction and move back and forth along the axial direction so that the first light irradiates the entire surface of the three dimensional object.

In an embodiment of the disclosure, the tank is filled with a liquid forming material, and the three dimensional printing apparatus further includes a third optical element located below the tank. Meanwhile, a second light is generated by the light source and transmitted by the third optical element to pass through the bottom of the tank to scan the liquid forming material, so that the liquid forming material is cured to form the three dimensional object on the modeling platform.

In an embodiment of the disclosure, the third optical element is a reflecting mirror.

In an embodiment of the disclosure, the first optical element and the third optical element are integrally structured.

In an embodiment of the disclosure, the first optical element is located at one side of the third optical element away from the light source.

In an embodiment of the disclosure, the second optical element is an oscillating mirror.

In an embodiment of the disclosure, the first light is sequentially transmitted by the first optical element and the second optical element to irradiate the three dimensional object along a second plane. The modeling platform moves out or in the tank along an axial direction which is parallel with the second plane.

In an embodiment of the disclosure, the modeling platform drives the three dimensional object to rotate in the axial direction so that the first light irradiates the entire surface of the three dimensional object.

In an embodiment of the disclosure, the three dimensional printing apparatus is a stereolithography (SLA) three dimensional printing apparatus.

Based on the above, in the embodiments of the disclosure, the light source not only cures the liquid forming material to form the three dimensional object, with the configuration of the first optical element and the second optical element relative to the tank, the light source also generates the first light that is transmitted by the first and second optical elements and detours round the tank to irradiate the three dimensional object moved out of the tank, thereby performing final appearance curing irradiation to the formed three dimensional object. Accordingly, the three dimensional printing apparatus does not need to be equipped with an additional space and device to achieve the above mentioned final irradiation, thereby improving the fabrication efficiency of three dimensional printing and lowering the fabrication cost for the apparatus.

To make the aforementioned and other features and advantages of the disclosure more comprehensible, several embodiments accompanied with drawings are described in detail as follows.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a side view illustrating a three dimensional printing apparatus according to an embodiment of the disclosure.

FIG. **2** shows a three dimensional printing apparatus according to FIG. **1** from another viewing angle.

FIG. **3** is a schematic three dimensional view illustrating partial components of the three dimensional printing apparatus according to FIG. **1**.

FIG. **4** is a side view illustrating a three dimensional printing apparatus according to another embodiment of the disclosure.

FIG. **5** is a side view illustrating a three dimensional printing apparatus according to another embodiment of the disclosure.

DESCRIPTION OF EMBODIMENTS

FIG. **1** is a side view illustrating a three dimensional printing apparatus according to an embodiment of the disclosure. FIG. **2** shows a three dimensional printing apparatus according to FIG. **1** from another viewing angle. Please refer to both FIG. **1** and FIG. **2**. In the embodiment, a three dimensional printing apparatus **100** is, for example, a stereolithography (SLA) three dimensional printing apparatus which includes a tank **110**, a modeling platform **120**, a first optical element **130**, a second optical element **140**, a light source **150**, and a third optical element **160**. The tank **110** is filled with a liquid forming material **300**. The modeling platform **120** is controlled by a controller (not shown) and is movably disposed on the tank **110**, so that the modeling platform **120** may move back and forth along a Z axis to achieve the movement status of moving the tank **110** in or out and the liquid forming material **300** therein. The light source **150** and the third optical element **160** are disposed below the tank **110**, wherein the third optical element **160** is, for example, a reflecting mirror. The light source **150** generates a second light L**2** which is transmitted by the third optical element **160** to be reflected towards the bottom of the tank **110**, and passes through the tank **110** to irradiate the liquid forming material **300** between the modeling platform **120** and the tank **110**. Since the liquid forming material **300** is, for example, a photosensitive resin, and the light source **150** generates the light (such as an ultraviolet) that may cure the photosensitive resin, with the scanning characteristics of the second light L**2** and the reflecting effect provided by the third optical element **160**, the second light L**2** may perform scanning to cure the liquid forming material **300** layer by layer on the modeling platform **120**. Finally, a three dimensional object **200** may be formed on the modeling platform **120**.

First, the method for forming the three dimensional object is described as follows. FIG. **3** is a schematic three dimensional view illustrating partial components of the three dimensional printing apparatus according to FIG. **1**. Please refer to both FIG. **1** and FIG. **3**. In the embodiment, the light source **150** includes a light emitting element **152** and an oscillating mirror module **154**, wherein the light emitting element **152** is, for example, an ultraviolet laser light source, which should not be construed as a limitation to the disclosure. The oscillating mirror module **154** is formed of two oscillating mirrors **154***a* and **154***b*, and one of the oscillating mirrors **154***a* and **154***b* is driven by a motor (not shown) so as to drive the second light L**2** generated by the light emitting element **152** to scan back and forth along an X-axis direction. The other one of the oscillating mirrors **154***a* and **154***b* is also driven by a motor (not shown) so as to drive the second light L**2** generated by the light emitting element **152** to scan back and forth along a Y-axis direction. Accordingly, the second light L**2** may perform scanning within a specific range (see the dash-lined frame drawn on the third optical element **160** as shown in FIG. **3**) of the third optical element **160** via the oscillating mirror module **154**, and the specific range includes the bottom of the tank **110**. In that case, the three dimensional printing apparatus **100** may control the scan range of the second light L**2** on the modeling platform **120** via the controller, and cure the liquid forming material **300** to form the three dimensional object **200** layer by layer with a desired outline.

Please also refer to FIGS. **1**-**3**. After the three dimensional object is formed, the modeling platform **120** is controlled by the controller to move the three dimensional object **200** out of the tank **110**. In the embodiment, the first optical element **130** and the second optical element **140** of the three dimensional printing apparatus **100** are, for example, reflecting mirrors which are respectively disposed next to the tank **110**. The first optical element **130** is disposed at one side of the third optical element **160** away from (opposite to) the light source **150**. The second optical element **140** is located above the first optical element **130**. Accordingly, when the three dimensional object **200** is moved out of the tank **110** to be located above the tank **110**, the light source **150** may be controlled by the controller to generate the first light L**1** having a different emitting angle from that of the second light L**2**, and allows the first light L**1** to be sequentially transmitted by the first optical element **130** and the second optical element **140** to detour round the tank **110** and irradiate the three dimensional object **200**, thereby performing final curing irradiation on the three dimensional object **200**.

Specifically, please also refer to FIG. **2**, which is illustrated based on a viewing angle V**1** according to FIG. **1**. Please note that, since the light source **150**, the first optical element **130**, and the second optical element **140** are located at different height along the Z axis, the three dimensional viewing angle of FIG. **2** will be described based on the three dimensional coordinates drawn by solid lines and the three dimensional coordinates drawn by dashed lines respectively.

In the embodiment, as mentioned above, the first light L**1** generated by the light emitting element **152** becomes the first light L**1** scanning within a specific range after being transmitted by the oscillating mirror module **154**. Therefore, when being reflected sequentially by the first optical element **130** and the second optical element **140**, the first light L**1** substantially scan the three dimensional object along an X-Y plane. That is, at the time, the outline generated by the first light L**1** irradiating the three dimensional object **200** is shown as a straight light along the X axis. Here, the X-Y plane is defined as a first plane. Therefore, the axial direction (Z axis) that the controlled modeling platform moves along is a normal direction of the first plane. Accordingly, the modeling platform **120** needs to be controlled by the controller to move back and forth along the Z axis while rotating in the Z axis so that the first light L**1** to irradiates the entire surface of the three dimensional object **200**.

FIG. **4** is a side view illustrating a three dimensional printing apparatus according to another embodiment of the disclosure. Different from the above embodiment, a second optical element **440** of a three dimensional printing apparatus **400** is an oscillating mirror, which is similar to the above oscillating mirrors **154***a* and **154***b*. However, the second optical element **440** of the embodiment generates a first light L**1** which scans along a Y-Z plane, that is, an oscillating axis of the second optical element **440** is the X axis. In other words, as the scan range of the first light L**1** reflected by the second optical element **440** is defined as the second plane, the axial direction (Z axis) which the controlled modeling platform **120** moves along is parallel with the second plane. Accordingly, the outline generated by the first light L**1** irradiating the three dimensional object **200** is shown as a straight line along the Z axis. At the time, the modeling platform **120** is simply controlled by the controller to rotate in the Z axis so that the first light L**1** irradiates the entire surface of the three dimensional object **200**.

FIG. **5** is a side view illustrating a three dimensional printing apparatus according to another embodiment of the disclosure. Different from the previous embodiment, in a three dimensional printing apparatus **500** of the embodiment, the first optical element and the third optical element are integrally formed as a reflecting mirror **530**, which is divided into reflecting surfaces **530***a* and **530***b* respectively (to avoid a complicated drawing of lines, the reflecting surfaces **530***a* and **530***b* are labeled at the rear side of the reflecting mirror **530**, but the reflection actually takes place at where the light L**1** and light L**2** are reflected as shown in the drawing). The reflecting surface **530***a* is substantially located right below the tank **110** so that the second light L**2** generated by the light source **1150** may scan on the modeling platform **120** after being transmitted by the reflecting surface **530***a* for curing the liquid forming material **300**. The reflecting surface **530***b* is substantially located outside the orthographic projection of the tank **110** projected on the reflecting mirror **530**, i.e. located at the opposite side of the reflecting surface **530***a* (away from) the light source **150** so that the first light L**1** generated by the light source **150** may be reflected on the second optical element **440** after being transmitted by the reflecting surface **530***b*. Moreover, the second optical element **440** in the embodiment is the same as shown in the embodiment of FIG. **4**; therefore, no further descriptions are incorporated herein.

Based on the above, in the embodiments of the disclosure, with different configurations of optical elements of the three dimensional printing apparatus, the light source cures the liquid forming material to form the three dimensional object. Also, with configuration of the first optical element and the second optical element relative to the tank, the light source may generate the first light that does not cure the liquid forming material; after being transmitted by the first and the second optical elements to detour round the tank and irradiate the three dimensional object moved out of the tank, the first light performs final appearance curing irradiation to the formed three dimensional object.

In addition, as the form of the second optical element changes adaptively, the first light may scan the three dimensional object outside the tank along different planes (such as the first plane or the second plane) so that the modeling platform operates under different movement statuses, allowing the entire surface of the three dimensional object to be irradiated by the first light and fully cured.

Accordingly, the three dimensional printing apparatus does not need to be equipped with an additional space and devices to achieve the above-mentioned final irradiation, and therefore the fabrication efficiency of three dimensional printing may be improved and the fabrication cost for the apparatus may be reduced.

It will be apparent to those skilled in the art that various modifications and variations can be made to the disclosed embodiments without departing from the scope or spirit of the disclosure. In view of the foregoing, it is intended that the disclosure covers modifications and variations provided that they fall within the scope of the following claims and their equivalents.

What is claimed is:

1. A three dimensional printing apparatus, comprising:

a tank filled with a liquid forming material;

a modeling platform moveably disposed above the tank to move in or out the tank;

a first optical element and a second optical element respectively disposed next to the tank, and the second optical element located above the first optical element;

a third optical element located under the tank; and

a light source located below the tank, wherein, when a three dimensional object is formed at the modeling platform, the modeling platform moves the three dimensional object out of the liquid forming material in the tank, and the light source generates a first light sequentially transmitted by the first optical element and the second optical element to detour round the tank to irradiate the three dimensional object to perform a final appearance curing irradiation to the formed three dimensional object,

wherein the light source generating a second light transmitted by the third optical element to pass through a bottom of the tank and scan the liquid forming material to cure the liquid forming material so as to form the three dimensional object on the modeling platform,

wherein the first optical element is located at a side of the third optical element away from the light source and out of an area under the tank.

2. The three dimensional printing apparatus according to claim **1**, wherein the modeling platform moves out or in the tank along an axial direction, and the modeling platform rotates in the axial direction.

3. The three dimensional printing apparatus according to claim **1**, wherein the first optical element and the second optical element are respectively a reflecting mirror.

4. The three dimensional printing apparatus according to claim **3**, wherein the first light is sequentially transmitted by the first optical element and the second optical element to scan the three dimensional object along a first plane, and the modeling platform moves out or in the tank along an axial direction which is a normal direction of the first plane.

5. The three dimensional printing apparatus according to claim **4**, wherein the modeling platform drives the three dimensional object to rotate in the axial direction and move back and forth along the axial direction so that the first light irradiates an entire surface of the three dimensional object.

6. The three dimensional printing apparatus according to claim **1**, wherein the third optical element is a reflecting mirror.

7. The three dimensional printing apparatus according to claim **1**, wherein the first optical element and the third optical element are integrally structured.

8. The three dimensional printing apparatus according to claim **1**, wherein the second optical element is an oscillating mirror.

9. The three dimensional printing apparatus according to claim **8**, wherein the first light is sequentially transmitted by the first optical element and the second optical element to irradiate the three dimensional object along a second plane, and the modeling platform moves out or in the tank along an axial direction which is parallel with the second plane.

10. The three dimensional printing apparatus according to claim **9**, wherein the modeling platform drives the three dimensional object to rotate in the axial direction so that the first light irradiates an entire surface of the three dimensional object.

11. The three dimensional printing apparatus according to claim **1**, wherein the three dimensional printing apparatus is a stereolithography (SLA) three dimensional printing apparatus.

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